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This program is addressing the need for diagnostic instrumentation to detect the presence of hidden chemical corrosion occurring at aircraft titanium and aluminum alloys. The approach is being directed towards development of pettern recognition schemes based upon the initial on-line acquisition of electrochemical impedance spectra using Fast Fourier Transfor Electrochemical Impedance Spectroscopy (FFTEIS) instrumentation from the suspect corrosion site.

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"ELECTROCHEMICAL IMPEDANCE PATTERN RECOGNITION FOR DETECTION OF HIDDEN CHEMICAL CORROSION ON AIRCRAFT COMPONENTS"

Bi-Monthly Technical Progress Report Number 1

on

DOD SBIR Contract No. F49620-94-C-0043, DEF
for the period June 15, 1994 - August 14, 1994

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August 1994

This program is addressing the need for diagnostic instrumentation to detect the presence of hidden chemical corrosion occurring at aircraft titanium and aluminum alloys. The approach is being directed towards development of pattern recognition schemes based upon the initial on-line acquisition of electrochemical impedance spectra using Fast Fourier Transform Electrochemical Impedance Spectroscopy (FFTEIS) instrumentation from the suspect corrosion site.

The contract Task 1 goal was to develop and implement Fast Fourier Transform Electrochemical Impedance Spectroscopy (FFTEIS) hardware and verify hardware performance on Al2024, Al7075 and Ti15,3,3,3 alloy working electrodes as potential corrosion sites. This goal was successfully achieved. Hardware developed included an instrumental differential amplifier, stepwise variable gain amplifier and dual matched characteristic six pole Bessel type low pass filters (schematically shown in Figure 1). Bessel filters have linear phase shift there-

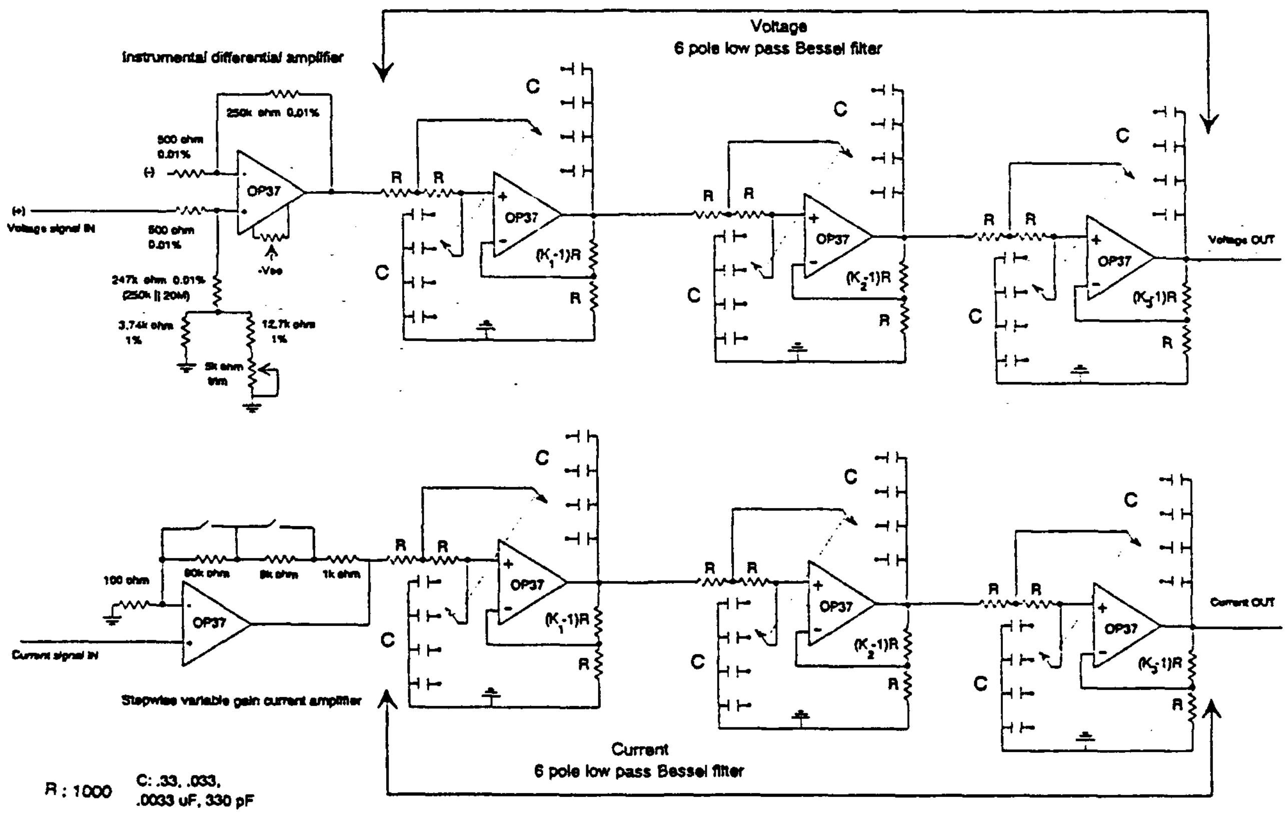

Figure 1. Instrumental differential and stepwise variable gain amplifiers followed by Dual matched characteristic 6 pole Bessel filters. Small voltage and current cell responses amplified for analog-to-digital conversion and filtered of pseudo-white-noise artifacts designed and fabricated at Eltron Reseaich, Inc. during Task 1 of this program.

by making them ideal for this application. Data acquisition system hardware incorporating 12 bit dual digital-to-analog and dual analog-tc-digital was programmed to apply pseudo-white-noise characterized by random phase to the working electrode alloys and acquire the time domain voltage and current response for over four frequency intervals. Filter roll-off 3 db points were established at 30 kHz, 3 kHz, 300 Hz and 30 Hz to prevent digital-to-analog conversion aliasing. 60 Hz and integer multiples were prevented from introducing noise by implementing frequencies based on prime numbers. A Stonehart BC1200 potentiostat interfaced the data acquisition system to the electrochemical cell; voltage and current responses were put through the amplifiers/filters and subsequently FFT transformed in a 486 based PC. FFT produced impedance phase and magnitude data were obtained and validated against conventional impedance spectroscopy for one of each type of alloy in three 0.1 molar electrolyte solutions, of HNO_3, H_2SO_4 and KNO_3. After making adjustments as needed, including analysis with series resistor and capacitor circuits, correlation of electrochemical cell parameters with conventional EIS demonstrated that the FFTEIS equipment was operating properly.

FFTEIS was performed on bare alloy samples to serve as the baseline for hidden corrosion results (Figure 2). Coupons of each alloy and each combination of alloys were spot welded or clamped together to form simulated hidden corrosion sites. These samples will be used during the majority of Task 2; "FFTEIS Measurements on Relevant Metal Substrates Subjected to Hidden Chemical Corrosion."

As discussed performance with contract goals and schedule is on plan.

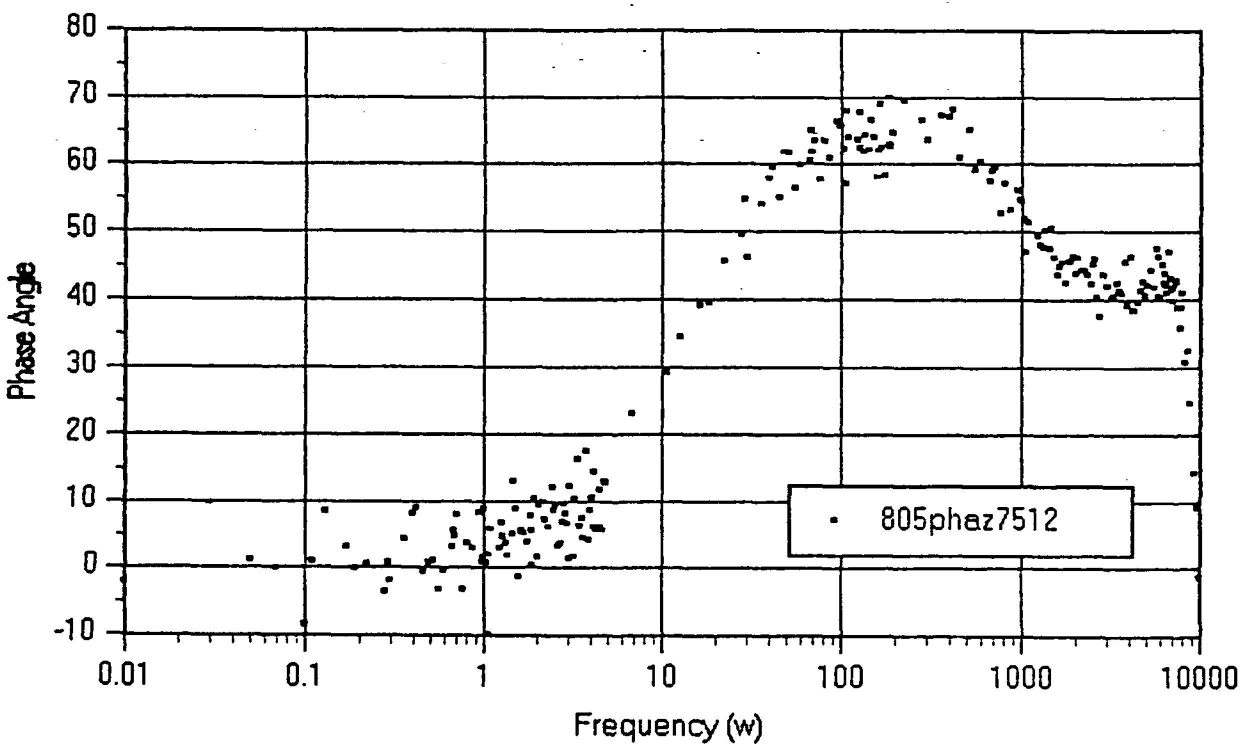

Figure 2. Baseline phase angle vs. frequency for alloy Al7075 in 0.1M H_2SO_4.